

PHILIPS



**MINIATURE RECORDER
PR 2400A**

66 441 48-1-10

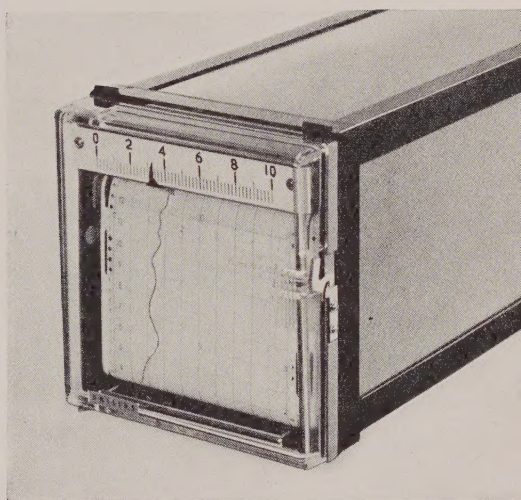
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MP MASTER



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PHILIPS

Directions for use

**MINIATURE RECORDER
PR 2400A**

66 441 48-1-10

1/663

Important!

In any correspondence concerning this apparatus the type number and the serial number should be stated; these are indicated on the type plate at the front of the frame (behind the cassette).

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GENERAL PART

Introduction

The PHILIPS miniature recorder PR 2400 A has been designed for measuring and recording temperatures with the aid of thermocouples and mV-direct voltages.

The working of the apparatus is based on the principle of automatic compensation of the unknown voltage by means of a servo-mechanism.

A temperature-dependent resistor can be incorporated into the measuring circuit, so that temperature measurements can be carried out with automatic cold-junction compensation.

For temperature measurements the apparatus should be provided with a measuring-range unit and a scale with the letter A in the type number; for measuring mV-direct voltages the apparatus must be equipped with a measuring-range unit and a scale with the letter M in the type number.

The measuring range can be altered by exchanging the measuring-range unit, in which case the scale must also be replaced in general.

The chart is fitted on a detachable cassette, so that it can be exchanged easily.

The apparatus has been designed for incorporation into a panel.

The fixing frame and the fixing nuts intended for this purpose are supplied with the apparatus.

The miniature recorder can be supplied in various versions, provided with slave potentiometer, a provision for increasing the chart speed, a setpoint unit, a mechanical signalling unit or a combination of two or three of these possibilities, see chapter "VERSIONS", page 6.

The principal parts of the apparatus are shown in the Figures 35...39 on page 50; the names of the parts are mentioned in the legend opposite.

Versions

The miniature recorder is supplied in the following versions:

- PR 2400 A/00 standard version
- PR 2400 A/01 with slave potentiometer 380 Ω
- PR 2400 A/02 with setting for high chart speeds
- PR 2400 A/03 with slave potentiometer 380 Ω and setting for high chart speeds
- PR 2400 A/04 with slave potentiometer 2000 Ω
- PR 2400 A/05 with slave potentiometer 2000 Ω and setting for high chart speeds
- PR 2400 A/11 with single setpoint and slave potentiometer 380 Ω
- PR 2400 A/13 with single setpoint and slave potentiometer 380 Ω and setting for high chart speeds
- PR 2400 A/14 with single setpoint and setting for slave potentiometer 2000 Ω
- PR 2400 A/15 with single setpoint, slave potentiometer 2000 Ω and setting for high chart speeds
- PR 2400 A/21 with double setpoint and slave potentiometer 380 Ω
- PR 2400 A/23 with double setpoint, slave potentiometer 380 Ω and setting for high chart speeds
- PR 2400 A/24 with double setpoint and slave potentiometer 2000 Ω
- PR 2400 A/25 with double setpoint, slave potentiometer 2000 Ω and setting for high chart speeds
- PR 2400 A/30 with signalling unit (1 microswitch)
- PR 2400 A/31 with signalling unit (1 microswitch) and slave potentiometer 380 Ω
- PR 2400 A/34 with signalling unit (1 microswitch) and slave potentiometer 2000 Ω
- PR 2400 A/40 with double signalling unit (2 microswitches)
- PR 2400 A/51 with single setpoint, signalling unit (1 microswitch) and slave potentiometer 380 Ω
- PR 2500 A/54 with single setpoint, signalling unit (1 microswitch) and slave potentiometer 2000 Ω

The directions for use apply to all afore-mentioned versions. It is explicitly stated when data or indications only relate to some of the above-mentioned versions.

Supplied parts

- 1 chart cassette
- 2 rolls of recording paper in air-tight packing. Do not remove the packing before the rolls are used. The type number of the chart is indicated at the rear of the scale.
- 6 glands

Contents of the service kit supplied:

- 1 bottle of oil
- 1 rubber bellows
- 1 tube of ink
- 1 pair of tweezers
- 1 cylinder with rubber discs
- 1 cylinder with rubber rings (diameter of the holes: 5 mm)
- 1 box, containing:
 - 1 capillary
 - 1 cylinder with piercers
 - 1 capillary hose
- 2 brushes
- 1 flannel duster

In case of repeat orders for these parts please apply to the PHILIPS Service Organisation.



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Fig. 1. Service kit

Technical data

Case	: Front dimensions: 144×144 mm. Suitable for incorporation into a panel. Required panel opening: $138^{+1} \times 138^{+1}$ mm. Space required behind the panel: 511 mm. Sheet steel, dripwater-tight, aluminium hammer-tone finish. Cable inlet through glands in a connection box at the rear of the case.	
Maximum ambient temperature	:	40 °C
Supply	:	220 V, 50 c/s
Power consumption	:	approx. 17 VA
Weight	:	approx. 12 kg
Transistors and diodes	:	$6 \times \text{OC } 45$ $4 \times \text{OA } 5$ $1 \times \text{OC } 72$ $2 \times \text{OA } 85$ $1 \times \text{OC } 30$ $4 \times \text{OA } 210$ $2 \times \text{ASZ } 15$ $1 \times \text{Z } 8$
Chart	:	length : approx. 16 m width : 100 mm visible length: 100 mm Provision for checking during recording a part of the recordogram which has already been wound up (max. 80 cm).
Chart speed	:	adjustable to 10, 20 and 60 mm/h For the PR 2400 A/.2, PR 2400 A/.3 and PR 2400 A/.5 the following speeds moreover apply: 600, 1200, 3600 mm/h.
Thickness of the recorded line:	:	approx. 0.3 mm
Contents of the ink container:	:	2.5 cm ³

Accuracy	:	$\pm 0.5 \%$ of the full-scale value for a measuring range of 10 mV and higher. For smaller measuring ranges, the accuracy is proportionally smaller. $\pm 1 \%$ of the full-scale value after replacement of the measuring-range unit, without recalibration.	
Maximum measuring range to be used	:	250 mV $\overline{\text{m}}$	
Reproducibility	:	$\pm 0.2 \%$ of the measuring range.	
Maximum loss of accuracy with mains voltage variations of $\pm 10 \%$	:	$\pm 0.1 \%$	
Maximum travel of the measuring carriage		101.4 mm	
Length of scale	:	100 mm	
Maximum balancing time for full-scale deflection	:	1 sec	
Carriage driving force	:	$> 350 \text{ g}$	
Damping of the measuring carriage	:	critically adjustable	
Maximum sensitivity of the servo-system	:	20 $\mu\text{V}\overline{\text{m}}$	
Supply current of the compensating circuit	:	1 mA $\overline{\text{m}}$, $\pm 0.1 \%$	
Measuring potentiometer	:	resistance	300Ω , $\pm 0.1 \%$
		winding length	209 mm = 311°
		number of windings	approx. 1040
		linearity	$\pm 0.2 \%$
Maximum permissible alternating voltage on the input terminals	:	0.1 % of the measuring range	

12 *Technical data*

Maximum permissible alternating voltage between the input terminals and earth : $1 \times \text{measuring range}$

Maximum permissible direct voltage between the input terminals and earth : $1000 \times \text{measuring range}$; in view of the risk of arcing no higher than 100 V

Maximum permissible resistance of the voltage source : $200 \Omega/\text{mV}$

In the case of temperature measurements the cold-junction temperature can be compensated automatically. After this temperature compensation has been switched off the scale applies to a cold-junction temperature of 0°C .

Slave potentiometer	PR 2400 A/.1, /.3	PR 2400 A/.4, /.5
Resistance	: $380 \Omega, \pm 5 \%$	$2000 \Omega, \pm 0.1 \%$
Number of windings	: approx. 1040	approx. 1040
Deviation of the linearity	: $\leq \pm 0.2 \%$	$\leq \pm 0.2 \%$
Maximum permissible supply voltage	: $30 \text{ V}_{\sim}$	$60 \text{ V}_{\sim}$
Setpoint unit	PR 2400 A/1., /5.	PR 2400 A/2.
Number of setpoints	: one	two
Resistance of the potentiometer	: $2000 \Omega, \pm 0.1 \%$	$2000 \Omega, \pm 0.1 \%$
Reproducibility of the adjustment	: 0.2%	0.2%
Maximum power	: 1.5 W	1.5 W
Maximum reading error	: 0.6%	0.6%
Mechanical signalling unit	PR 2400 A/3., /5.	PR 2400 A/40
Number of switches	: one	two
Switching power	: $30 \text{ V}, 0.5 \text{ A}_{\sim}$	$30 \text{ V}, 0.5 \text{ A}_{\sim}$
Hysteresis in the circuit	: max. 1%	max. 1%

DIRECTIONS FOR USE

The numbers in parentheses in this chapter refer to the general view on page 50.

Mechanical installation

UNPACKING

The apparatus has been carefully packed before dispatch. Moreover the amplifier (23) and the frame (28) have been secured in position for transport.

Before the installation of the apparatus is started, the protective wooden frame and the devices with which the frame and the amplifier are secured have to be removed in the following way, see Figs. 2, 3 and 4.

1. Remove the four nuts and washers *a*, at the rear of the case.
2. Push the fixing frame *b* off the case.
3. Remove the protective wooden frame *c*.

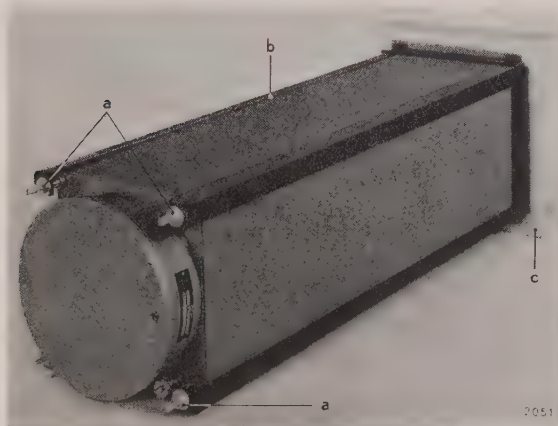


Fig. 2. Apparatus with fixing frame and protective frame

4. Open the door of the apparatus and remove the small block *d* at the front of the frame (loosen the screw).
5. By means of the grip (30) pull the frame as far out of the case as possible. Take care that the frame when pulled out is supported.
6. Remove the locking screw *e* from the amplifier.

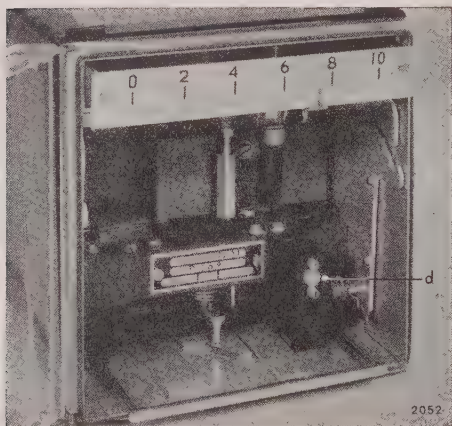


Fig. 3. Front view, frame secured

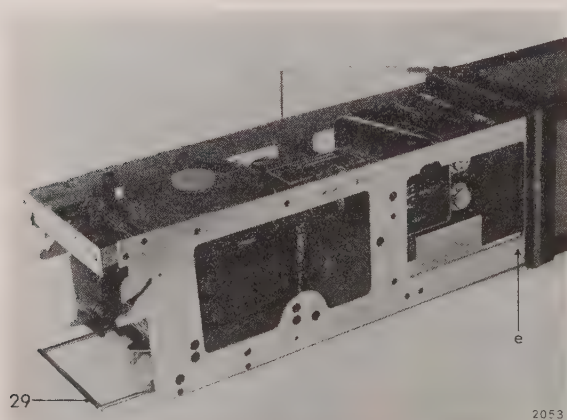


Fig. 4. Apparatus with the frame pulled out

It is recommended to keep all the packing material, the wooden protective frame, the small block and the locking screw, so as to be able to pack the apparatus in the same way in case of transport later on. This way of packing offers the best protection against damage during transport.

On no account use wood-wool as packing material!

BUILDING INTO A PANEL

a. General

Preferably place the apparatus in a well-lighted dust-free room with constant temperature. The dimensions of the required opening in the panel are indicated in Fig. 5. To make easy reading of the scale possible it is recommended to choose the centre line of the opening at least 1 meter above the floor.

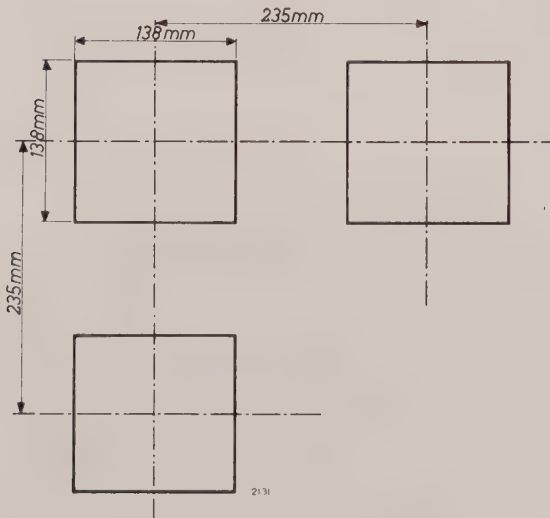


Fig. 5. Openings in the panel

Remember that after the apparatus has been built into the panel, the case projects about 510 mm from the rear of the panel. The thickness of the panel to be used must not exceed 10 mm.

If two apparatus are fitted one above the other the minimum centre-to-centre distance of the openings in the panel must be 235 mm, so that a hum filter can be fitted if required. If two apparatus are fitted one beside the other in a 19"-panel, the centre-to-centre distance of the openings may also be 235 mm, see Fig. 5, but should be a minimum of 185 mm.

Before the apparatus is placed in the panel the frame (28) must be removed from the case, in view of the weight of the apparatus. For this purpose the amplifier (23) must be taken out of the frame first.

b. Removing the amplifier from the frame

1. Pull the frame as far as possible out of the case by means of the grip (30); take care that the frame is supported.
2. Press the lever (19) of the amplifier to the left; the plugs of the amplifier are accordingly lifted from the sockets.
3. Pull the amplifier perpendicularly out of the frame by means of the grip (21); during this procedure keep the thumb pressed against the lever.

c. Removing the frame from the case

After the amplifier has been removed from the frame, the frame must be taken out of the case in the following way, see Fig. 6.

1. Pull the female plug *a* of the cable tree from the socket. The plug is accessible via the round opening at the rear of the frame.
2. Lift the spring-loaded locking pin *b*, which is also accessible via the opening at the rear of the frame, and pull the frame out of the case.

Note — The grip only serves to push the frame into or out of the case; therefore do not use it to carry the frame.

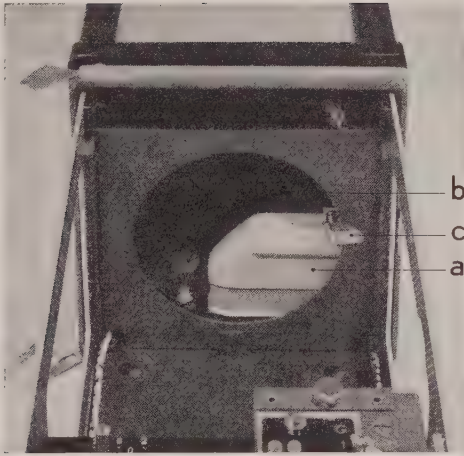


Fig. 6. Apparatus with the frame pulled out, amplifier removed

d. Fitting the case into the panel

Push the case of the apparatus as far as possible into the panel. Fit the symmetrical fixing frame (2) by pushing it over the case starting from the rear. Subsequently fit the fixing nuts and washers and tighten the nuts until the case is firmly clamped in the panel.

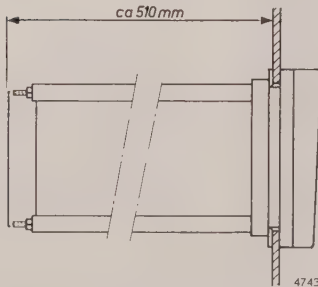


Fig. 7. Case mounted in the panel

The correct way of mounting is indicated in Fig. 7.

e. Fitting the frame in the case

1. Insert the female plug (*a*, Fig. 6), of the cable tree in the socket. Make sure that the hook *c* on the plug grips the rim of the round opening.
2. Push the frame into the case.

f. Fitting the amplifier in the frame

1. Lower the amplifier perpendicularly, see Fig. 8.
2. Press the amplifier as far as it goes so that the plugs of the amplifier are pressed into the sockets.

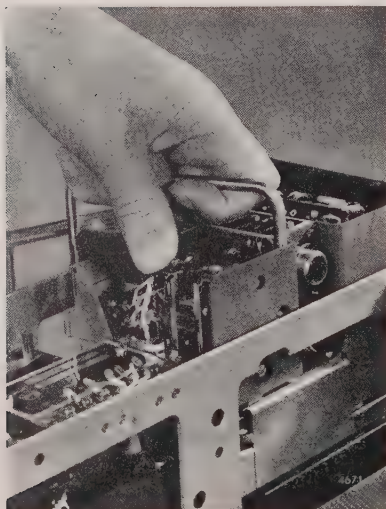


Fig. 8. Fitting the amplifier in the frame

Electrical installation

GENERAL

All connections of the apparatus are made at the terminals L4 and L5 (5) and D1...D12 (4) in the connection box (3) at the rear of the apparatus. These terminals are accessible after the lid (7) has been removed.

Fit the glands in the holes of the connection box, see Fig. 9. The glands are provided with small rubber rings with a hole of 8 mm. For leadings in cables with a diameter of 5 mm these rings can be replaced by others with a hole of 5 mm, which are found in the service kit. Glands not used can be stopped with the rubber discs (also supplied in the service kit).

The diameter of the connecting cables may amount to maximum 11 mm. In that case, however, the hole in the rubber ring of the gland must be enlarged.

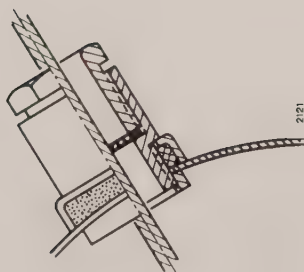
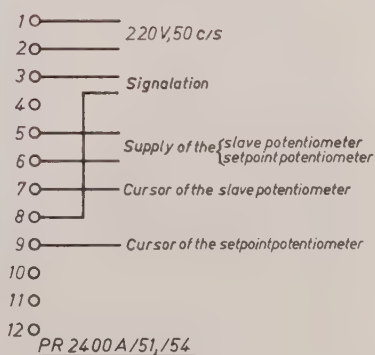
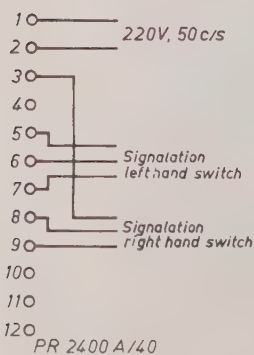
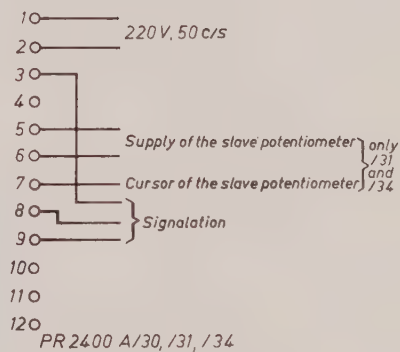
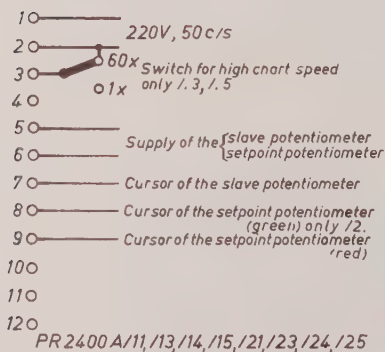
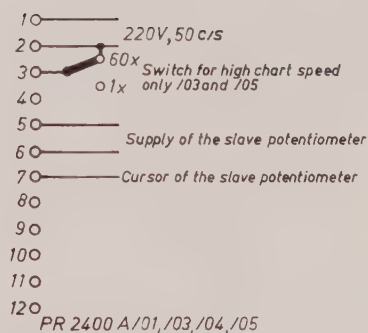
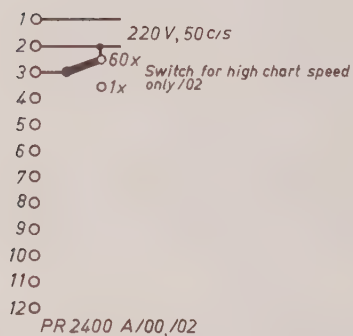


Fig. 9. Gland fitted in the connection box

The connection diagrams are given in Fig. 10.

20 Electrical installation



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Fig. 10. Connection diagrams

VOLTAGE SOURCE

a. Temperature measurements

Connect the cable of the thermocouple to the terminals L4 (—) and L5 (+).

In the case of temperature measurements for which the apparatus must be provided with a measuring-range unit and a scale with the letter A in the type number (e.g. PR 4162 A/01), a choice can be made of:

measurements with automatic cold-junction compensation and
measurements without automatic cold-junction compensation.

In this type of apparatus the scale is usually calibrated in °C.

For measurements *with* automatic cold-junction compensation the thermocouple must be connected by means of the corresponding compensation cable; this cable must preferably be screened.

The switch strip in the connection box must be placed between the terminals L1 and L2, see Fig. 11.

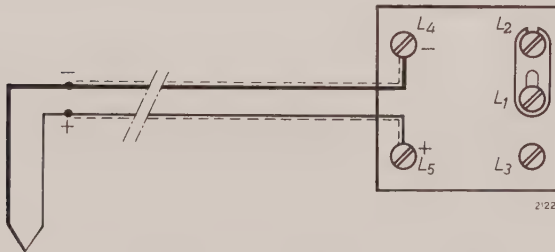


Fig. 11. Connection of a thermocouple for measurements with automatic cold-junction compensation

For measurements *without* automatic cold-junction compensation a cable with copper conductors, preferably screened, must be used for the connection between the cold-junction and the terminals in the connection box.

The cold-junction must be kept constantly at 0 °C (cold-junction in melting ice).

The switch strip in the connection box must be placed between the terminals L1 and L3, see Fig. 12.

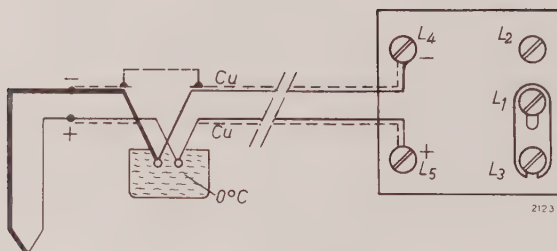


Fig. 12. Connection of a thermocouple for measurements without automatic cold-junction compensation

Note — With an apparatus equipped with an M-type measuring-range unit it is also possible to measure temperatures with the aid of a thermocouple. In that case however, since automatic cold-junction compensation is not possible, the cold-junction must be kept at a constant temperature.

The indication in mV (increased by the mV voltage adapted to the cold-junction temperature) can be converted into °C with the aid of the temperature/mV table of the thermocouple.

The switch strip in the connection box must be placed horizontally (no connection between the terminals L1, L2 and L3), see Fig. 13.

b. mV-measurements

Connect the cable to the terminals L4 (—) and L5 (+).

In the case of mV-measurements for which the apparatus must be provided with a measuring-range unit and a scale with the letter M in the type number (e.g. PR 4160 M/02), preferably use a screened cable.

The switch strip in the connection box must be placed in horizontal position (no connection between the terminals L1, L2 and L3), see Fig. 13.

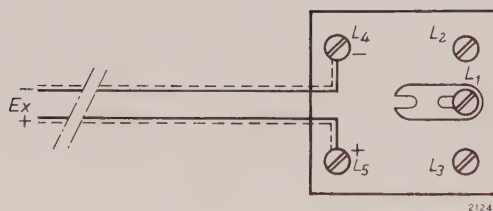


Fig. 13. Connection of an mV-voltage source

Note — Care should be taken that the connecting cable of the voltage source does not run parallel to cables carrying high alternating currents, in order to avoid interference voltages as much as possible. In order to prevent the connecting cable from being damaged and induction currents from occurring, it is advisable to place the cable in steel or annealed steel tubes respectively.

EARTHING

a. Case

Connect the earth terminal (8), already interconnected to D4 (see Fig. 10), to earth (earth rail or a copper or copper-clad pipe driven into the ground). As a result the case and the frame are earthed.

b. Voltage source

Earthing via the apparatus

On delivery of the apparatus L_4 is connected to terminal D10. As a result the minus pole of the connected voltage source is earthed via a capacitor ($16 \mu\text{F}$) between the terminals D10 and D4, see Fig. 14.

When a screened connecting cable is used the screening must be connected to D10.

Should the circuit connected be of such a nature that the dead zone is too large it may be necessary to earth the plus pole of the voltage

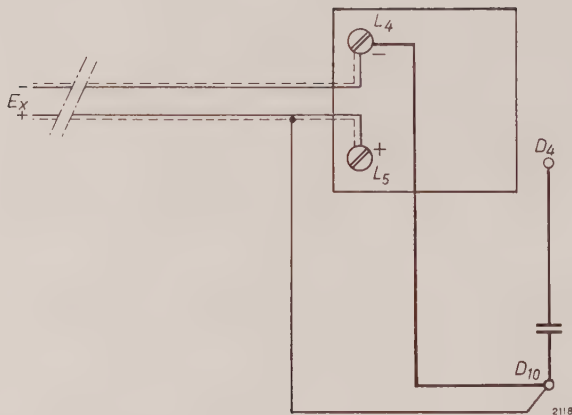


Fig. 14. Earthing via the apparatus (—pole earthed)

source (see "FAULT FINDING", page 57). The connection L_4 - D_{10} must then be removed and L_5 - D_{10} be fitted.

Earthing at the measuring point

If the voltage source is earthed at the measuring point the connection L_4 - D_{10} must be removed.

If the connecting cable is screened, the screening must also be earthed at the measuring point, see Fig. 15.

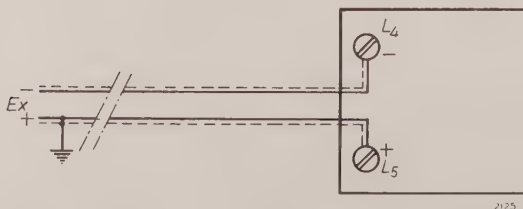


Fig. 15. Earthing at the measuring point

Note — It may occur that in spite of good earthing interference voltages arise in the measuring circuit. In this case consult the chapter "FAULT FINDING", page 57.

SLAVE APPARATUS

Only applies to PR 2400 A/.1, PR 2400 A/.3, PR 2400 A/.4 and PR 2400 A/.5

The slave potentiometer is connected to the terminals D5 (beginning), D6 (end) and D7 (sliding contact), see Fig. 16. These terminals can be used for the connection of a slave apparatus or a control unit.

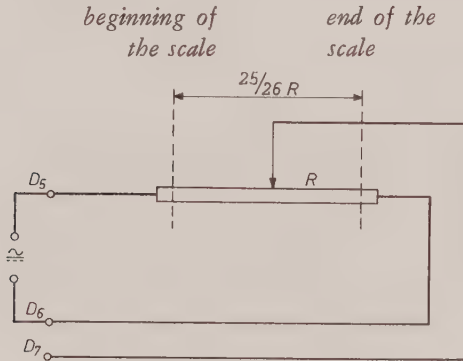


Fig. 16. Slave potentiometer

The supply voltage must be connected to the terminals D5 and D6; maximum supply voltage $30\text{ V}_{\sim}$ for the versions PR 2400 A/.1 and PR 2400 A/.3 and $60\text{ V}_{\sim}$ for the versions PR 2400 A/.4 and PR 2400 A/.5.

Note — It should be taken into account that the sliding contact of the slave potentiometer cannot cover all the windings of the poten-

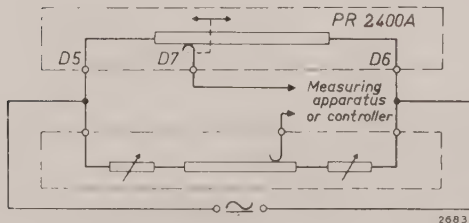


Fig. 17. Compensation of the residual resistance of the slave potentiometer

tiometer (Fig. 16). This means that when the measuring pointer (and also sliding contact D7) is at the zero point or the final point of the scale, there is a residual resistance between D5 and D7 and D6 and D7 respectively. This residual resistance amounts to about 2 % of the total resistance.

If necessary, this residual resistance must be compensated (outside the recorder). The most convenient way of doing so is by including the slave potentiometer in a bridge circuit, see Fig. 17.

SETPPOINT UNIT

Applies only to PR 2400 A/1., PR 2400 A/2. and PR 2400 A/5.

In these versions a setpoint potentiometer has been incorporated, which together with the slave potentiometer forms part of a bridge circuit. In the version PR 2400 A/2. the setpoint potentiometer has two sliding contacts which can be adjusted independent of one another.

The setpoint potentiometer is connected to the terminals D5 and D6 (supply) and terminal D9 (sliding contact). In the versions PR 2400 A/2. the second sliding contact (upper pointer) is connected to terminal D8.

SIGNALLING UNIT

Applies only to PR 2400 A/3., PR 2400 A/40 and PR 2400 A/5.

In these apparatus a microswitch has been incorporated, which is operated mechanically by means of the measuring potentiometer.

In the PR 2400 A/40 two microswitches are present. These microswitches are connected as follows:

PR 2400 A/3. to the terminals D3, D8 and D9

PR 2400 A/40 to the terminals D3, D8 and D9 (right-hand switch)
and to the terminals D5, D6 and D7 (left-hand switch)

PR 2400 A/5. to the terminals D3 and D8.

The terminals D8 and D5 are connected to the master contact of the microswitch. If the microswitches are depressed, the terminal D3 and D8 are interconnected and with the PR 2400 A/40 the terminals D5 and D7 as well.

The microswitches can be used for signalling or for on/off control. The maximum switching power amounts to 30 V, 0.5 A at ohmic load.

CONNECTION FOR HIGH CHART SPEEDS

Only applies to PR 2400 A/.2, PR 2400 A/.3 and PR 2400 A/.5

With apparatus with possibility for adjusting high chart speeds, the normal chart speeds can be increased by a factor 60. For this, the terminals D2 and D3 (in the connection box) must be interconnected. By effecting this connection via a switch (220 V, 1 A), the normal speeds as well as the high speeds can be selected. The switch can be fitted, for example, on the panel, so that it can be readily operated from outside the recorder.

CHECKING FOR INTERRUPTIONS IN THE MEASURING CIRCUIT IN THE CASE OF TEMPERATURE MEASUREMENTS

In the case of temperature measurements an indication of an interruption in the measuring circuit can be obtained by connecting to terminals L4 and L5 a dry battery of 1.5 V in series with a resistor of at least 10 M Ω , see Fig. 18.

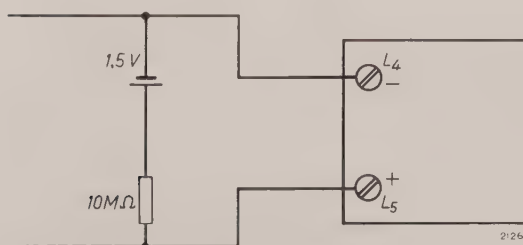


Fig. 18. Checking for interruptions in the measuring circuit in the case of temperature measurements

When an interruption in the measuring circuit arises, this is immediately indicated owing to the fact that the measuring carriage moves to the beginning or to the end of the scale (dependent on the polarity of the battery) and remains there.

When there is no interruption in the measuring circuit the battery voltage will hardly have any effect on the measuring result owing to the high series resistance. (With a partial interruption a wrong indication might be given.)

MAINS VOLTAGE

Connect the apparatus to 220 V, 50 c/s, mains voltage via terminals D1 and D2. When the mains voltage has another value a matching transformer (approx. 20 VA) should be used.

When the apparatus is installed permanently a switch and a fuse should be incorporated in the supply line.

Preparing for use

GENERAL

To prepare the apparatus for use proceed as follows:

1. Fit the chart on the cassette, see page 31.
2. Fill the ink container, see page 36.
3. Calibrate the supply current of the compensation system, see page 39.
4. Adjust the damping of the measuring carriage, see page 40.
5. Check the dead zone, see page 41.
6. Adjust the chart speed, see page 34.
7. Adjust the setpoint unit and the signalling unit (if present), see page 37.

Note — For the adjustment of the lowest chart speed it is recommended to eliminate the play in the gear transmission of the chart-driving mechanism by slightly turning the sprocket roller backwards.

CHART CASSETTE

a. Fitting the cassette in the frame

1. Place the cassette (29) in the frame (28), so that the pins P engage in the recesses of the grooves, see Fig. 19A.
2. Slightly lift the cassette so that the pins P and Q close against the tops of the grooves, see Fig. 19B.
3. Push on the cassette in an upward direction until it reaches a vertical position and press it on so that it is automatically locked in the frame, see Fig. 19C.

b. Removing the cassette from the frame

After pulling the frame forward the cassette can be removed from the frame by pulling it forward by the ribbed blocks.

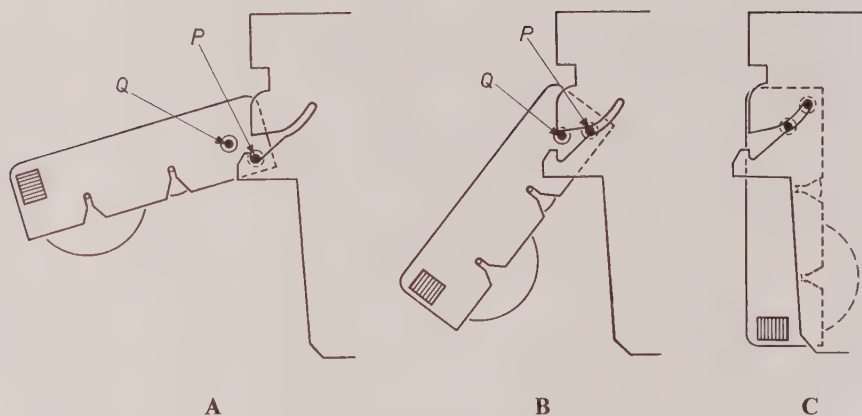


Fig. 19. Fitting the cassette in the frame

c. Checking the recordogram

A part of the recordogram that has already been wound can be checked during recording by pulling a part of the chart (approx. 80 cm) from the winding roller, see Fig. 20.

When the chart is released this is automatically rewound on the winding roller.



Fig. 20. Checking the recordogram

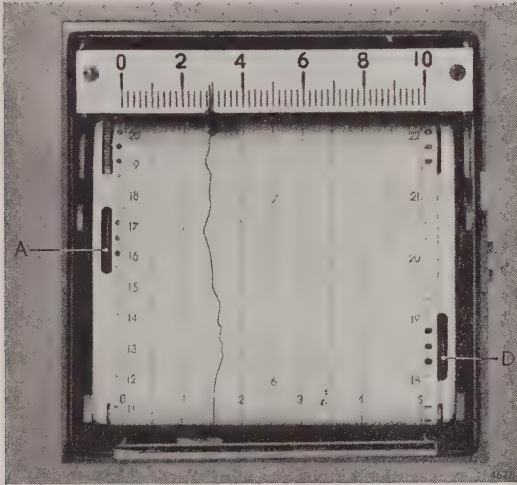


Fig. 21. Front view

d. Provision for rewinding

The chart can be rewound by turning the knurled wheel of the supply roller (A, Fig. 21) against the normal direction of rotation. During rewinding the chart-speed lever (17) must be at the 0-position. The chart can be rewound up to a length of approx. 80 cm.

CHART

a. Fitting the chart on the cassette

1. Place the cassette (29) in reverse position in the slots of the frame, see Fig. 22.
2. Take the supply roller A out of the cassette by pressing it slightly to the left and pull the roller by the knurled wheel from the cassette.
3. Insert the supply roller into the cylinder of the roll of paper at the side of the round perforations; press the roller into the cylinder until the chart touches the knurled wheel.

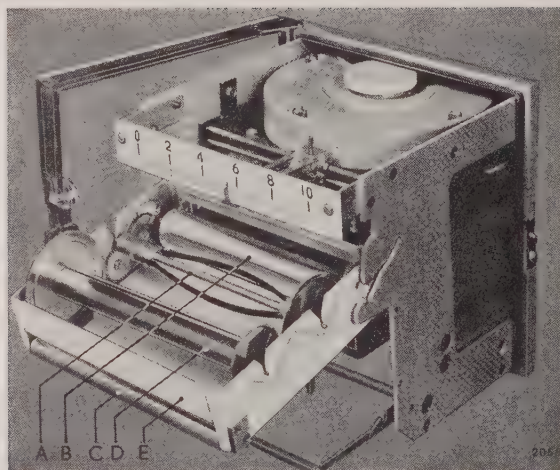


Fig. 22. Cassette placed in the slots of the frame in reverse position

4. Place the supply roller in the cassette again pressing the roller slightly to the left.
5. Unwind the chart about 30 cm, pass it over the sprocket roller B along the front plate between the guide roller C and the connecting strip E to the winding roller D, see Fig. 23.

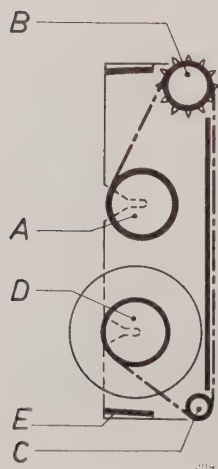


Fig. 23. Chart transport

6. Introduce the chart as far as possible under the spring of the winding roller and fold the end of the chart back over the spring.
7. Turn the winding roller (by the knurled wheel) until the chart is tight.
8. Place the cassette in the frame in the correct way.

Note — As an indication that the roll of recording paper is almost completely used up, the last metre of the chart is usually provided with a red line.

b. Exchanging the chart

When the chart has been completely used up it must be replaced by a new roll as follows.

1. Pull the frame so far out of the case that the cassette is easily accessible.
2. Remove the cassette from the frame.

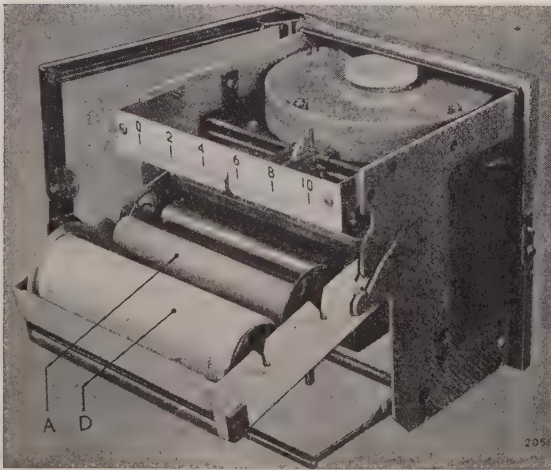


Fig. 24. Cassette placed in the slots of the frame in reverse position

3. Place the cassette in reverse position in the slots of the frame, see Fig. 24.

4. Turn the winding roller D until all the paper is wound on this roller.
5. Take the winding roller from the cassette. For this purpose push the winding roller to the right and pull the roller from the cassette by the knurled wheel.
6. Hold the winding roller in the hand and pull the knurled wheel F, so that this slides out of the cylinder G, see Fig. 25.

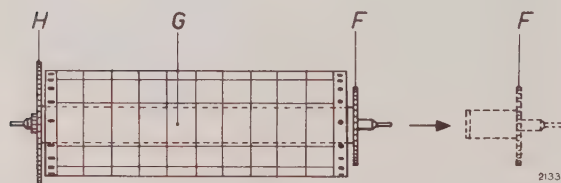


Fig. 25. Winding roller with chart

7. Turn the knurled wheel H to the left until cylinder G turns easily in the roll of paper.
8. Hold the chart firmly and push it from the cylinder; while doing so turn the roll of paper slightly to the right and to the left if required. Take care that the sides of the roll of paper remain flat.
9. Push the knurled wheel F into cylinder G again.
10. Place the winding roller into the cassette again, pressing it slightly to the right.
11. Take the supply roller A out of the cassette. For this purpose push the supply roller to the left and pull it out of the cassette by the knurled wheel.
12. Push the cardboard cylinder of the used-up roll of paper off the supply roller.
13. Fit a new roll of recording paper on the cassette in accordance with the indications given on page 31 in the chapter "Fitting the chart on the cassette", items 3...8.

c. Adjusting the chart speed

1. Normal speed

The chart speed can be adjusted to 10, 20 or 60 mm/h. For this purpose the frame must be withdrawn so far from the case that the lever for adjusting the chart speed (17) is easily accessible.



Fig. 26. Lever for adjusting the chart speed

The adjustment is effected by setting the lever at the desired position:

position 1: 10 mm/h

position 2: 20 mm/h

position 6: 60 mm/h

At the 0-position the driving motor is uncoupled.

Note — Mind the play in the gear transmission when using the lowest chart speed, see the note on page 29.

2. High speed

Only applies to PR 2400 A/.2, PR 2400 A/.3 and PR 2400 A/.5

After terminals D2 and D3 have been connected (e.g. by means of a switch, see page 27), the following chart speeds can be selected:

position 1: 600 mm/h

position 2: 1200 mm/h

position 6: 3600 mm/h

RECORDING SYSTEM

The recording system is accessible after the frame has been pulled forward and the cassette has been removed.

a. Filling the ink container (13), see Fig. 27

1. Unscrew the ink container *a* from the lid *e*.
2. Fill the ink container to just beneath the screw thread.
3. Screw the ink container on to the lid again.
4. Fit the loaded cassette in the frame.

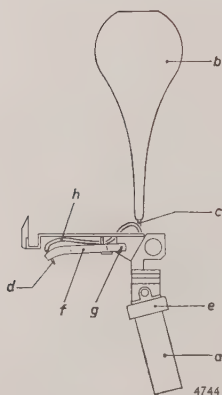


Fig. 27. Recording system

5. Place the bellows *b*, supplied in the service kit, on the tube *c*.
6. Squeeze the bellows; the ink is then forced through the small hose into the recording capillary *d*.
7. Pull the compressed bellows from the tube to prevent the ink from being drawn back from the capillary.

Always allow the capillary to rest on the chart, also when no recording is made. This prevents the ink from drying out and the capillary from getting clogged.

b. Cleaning the capillary (Fig. 27).

When the capillary has got clogged, it must be flushed clean with ink as follows.

1. Place the bellows *b*, supplied in the service kit, on the tube *c*.
2. Squeeze the bellows *carefully*; the hose and the capillary are now flushed. Collect the ink in a cloth or a container.

It is also permitted to flush the recording capillary with water instead of ink. In that case, clean the ink container and fill it with water; then flush the capillary in the way indicated above. If no favourable result is obtained with the above method, the capillary must be pierced. Proceed as follows.

1. Lift the two legs of the capillary bracket *f* from the pins *g*.
2. Slide the hose *b* off the capillary.
3. Push a piercer (service kit) through the capillary; remove the dirt and withdraw the piercer.
4. Slide the hose on to the capillary again.
5. Refit the capillary bracket.

Note — Take care that the capillary bracket is not bent, since good recording is only possible when the capillary rests flat on the chart.

SETTING

a. Setpoint unit

Applies only to PR 2400 A/1., PR 2400 A/2. and PR 2400 A/5.

The setpoint potentiometer can be adjusted to the required value with the aid of the knurled wheel, which is found at the right-hand side of the scale. The adjusted setpoint value can be read from the scale. In the case of the versions PR 2400 A/2. the knurled wheel at the right corresponds to the red pointer and the knurled wheel at the right to the green pointer. Both the gliding contacts can be adjusted fully indepent of one another.

b. Signalling unit

Applies only to PR 2400 A/3., PR 2400 A/40 and PR 2400 A/5.

Adjustment of the signalling unit is effected as follows.

1. Adjust the measuring pointer to the required switching point by turning the rope pulley (14) on the measuring potentiometer.

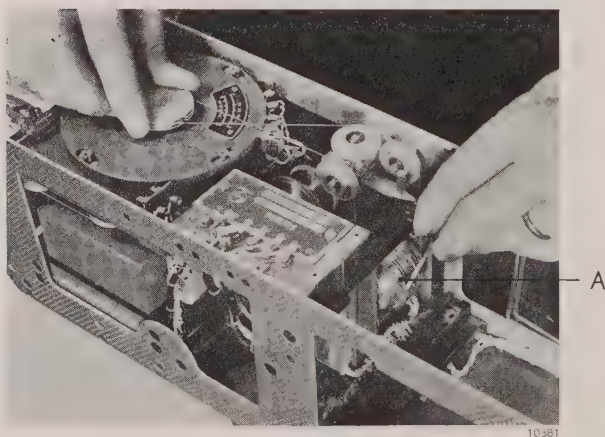


Fig. 28. Setting the switching point

2. From above insert the adjusting hook in one of the holes of the switching disc A and turn the switching disc by pushing the adjusting hook downwards until the microswitch is actuated (which can be heard and/or seen), see Fig. 28. In doing so, hold the rope pulley of the measuring potentiometer firmly.

Note — The adjusting hook must be pushed downwards and not be pulled upwards, because otherwise the drum is lifted, as a result of which the driving rope may run off the pulleys.

3. By turning the rope pulley of the measuring potentiometer make sure that the microswitch is actuated at the desired point. If necessary, readjust the switching disc slightly.

4. In the PR 2400 A/40 the two switching discs can be adjusted individually in the way described in items 1...3. The left-hand switch is connected to the terminals D5, D6 and D7, the right-hand switch to the terminals D3, D8 and D9.

Note — If the microswitch should switch on instead of switch off or the other way round, then the switching disc must be turned 360° as described in items 1...3.

ADJUSTMENT

Switch on the mains voltage. Withdraw the frame (28) as far as possible from the case so that the amplifier (23) becomes accessible.

a. Supply current of the compensating circuit

1. Set switch "SENSIT." (22) to position " < 20 ".
2. Turn potentiometer "SENSIT." (24) fully clockwise (maximum sensitivity).
3. Press button "CAL." (20) and move the measuring carriage by means of the knob on the measuring potentiometer (14) approximately to the middle of the scale.

4. Release the knob.

If the measuring carriage stops or moves very slowly to the left or to the right, the supply current is adjusted to the right value (1 mA).

If the measuring carriage moves to the beginning or to the end of the scale turn potentiometer "ADJ." (25) until the measuring carriage stops at an arbitrary point of the scale or moves very slowly to the left or to the right.

b. Damping of the measuring carriage

For adjusting the damping of the measuring carriage, make sure that the pointer is at the scale. It is important for the pointer to be movable by some 2 cm each way from its equilibrium position. The adjustment of the damping is done as follows.

1. Set switch "SENSIT." to position " < 20 ".
2. Make sure that potentiometer "SENSIT." is turned so far anti-clockwise that the measuring carriage stops oscillating.
3. Move the measuring carriage approx. 2 cm out of its position of equilibrium by means of the knob on the measuring potentiometer (14).

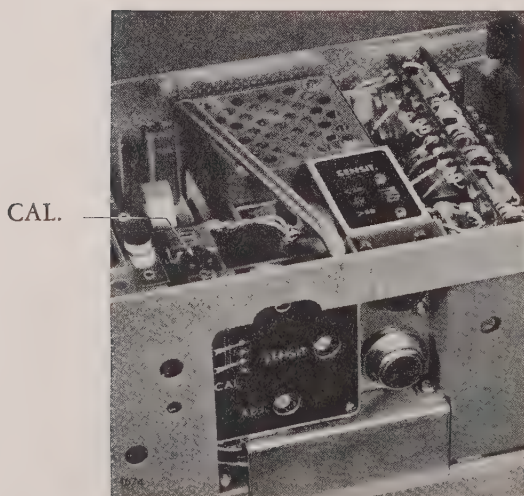


Fig. 29. Amplifier

4. When the knob is released, the measuring carriage will return critically damped to its position of equilibrium if the damping is correct.

If the measuring carriage overshoots its position of equilibrium, potentiometer "SENSIT." must be turned slightly further anticlockwise. If the measuring carriage moves too slowly to its position of equilibrium it must be turned slightly clockwise.

5. When it is not possible to adjust the apparatus critically, switch "SENSIT." must be set to position "> 50" (lower sensitivity).

Repeat the instructions given in items 2...4.

c. Dead zone

At the sensitivity adjusted as indicated above, the measuring carriage, if moved by means of the knob of the measuring potentiometer approx. 2 cm out of its position of equilibrium to either side, will return to the position of equilibrium after the knob has been released.

In general this will not be so, but two positions of equilibrium will arise. The zone between these positions of equilibrium – dead zone – (carriage released from the left and from the right) must not exceed 0.2 mm.

If the dead zone exceeds this value and cannot be adjusted with potentiometer "SENSIT.", proceed as indicated in chapter "FAULT FINDING" page 57.

Exchanging the measuring-range unit and the scale

When a different measuring range is required the measuring-range unit (18) and the scale fitted in the apparatus must be replaced.

Note — Besides the type number of the scale itself, the type numbers of the relevant measuring-range unit and chart are also indicated at the rear of the scale.

a. Removing the measuring-range unit

1. Switch off the mains voltage.
2. Pull the frame so far out of the case that the measuring-range unit is easily accessible.
3. Detach the connections G1...G5.
4. Loosen the knurled screw and raise the unit, see Fig. 30.
5. Remove the four screws *a* from the hinges and take the unit out of the frame.



Fig. 30. Measuring-range unit tipped up

b. Fitting the new measuring-range unit

1. Fit the new measuring-range unit; tighten the fixing screws of the hinges but not too firmly.

2. Lower the unit and tighten the knurled screw.
3. Tighten the four screws of the hinges firmly. These screws are accessible via the opening at the side of the frame.
4. Restore the connections G1...G5:
 - terminal G1: green
 - terminal G2: white
 - terminal G3: yellow
 - terminal G4: red
 - terminal G5: blue

c. Adjusting the measuring carriage to zero

1. Detach the connecting wires of the voltage source on the terminals L4 and L5 and apply to them a voltage (e.g. from a compensator), the magnitude of which is exactly equal to the initial value of the scale. If the initial value is zero, these terminals must be short-circuited.
2. Check whether the switch strip (6) is at the right position; for temperature measurements between L1 and L3 (no automatic cold-junction compensation), for mV-measurements no connection between L1, L2 and L3.

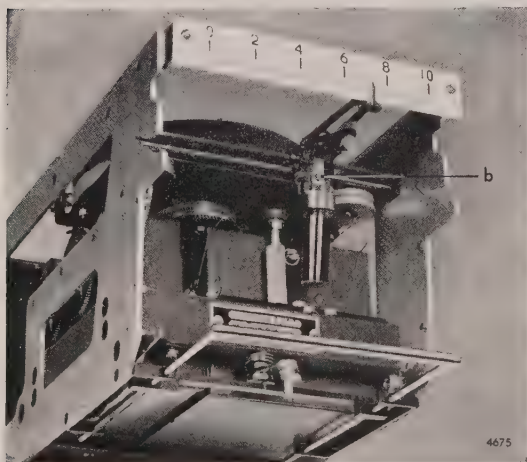


Fig. 31. Front view of the frame, cassette removed

3. Switch on the mains voltage; the capillary must now coincide with the initial line of the chart. If this is not the case, proceed as follows.
4. Pull the frame so far out of the case that the knob of the measuring potentiometer (14) is easily accessible.
5. Pull the cassette out of the frame by the ribbed blocks.
6. Loosen the small screw *b* (Fig. 31).
7. Place the cassette into the frame again, see page 27.
8. Hold the knob of the measuring potentiometer and slide the *measuring carriage* until the capillary is exactly at the zero line.
9. Take the cassette out of the frame and tighten screw *b*.

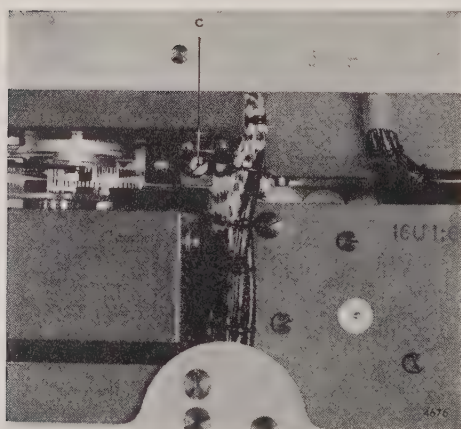


Fig. 32. *Right-hand side of the frame, with stop screw for limiting the travel (beginning)*

10. Check whether the stop screw *c* (Fig. 32) for limiting the travel of the measuring carriage at the beginning of the scale is so adjusted that when the knob on the measuring potentiometer has been turned fully clockwise, the capillary is approx. 0.5 mm before the initial line of the chart. If desired, readjust the stop.

11. Check whether the stop screw d (Fig. 33) for limiting the travel of the measuring carriage at the end of the scale is so adjusted that when the knob on the measuring potentiometer has been turned fully anti-clockwise the capillary is approx. 0.3 mm after the final line of the chart. If desired, readjust the stop.



Fig. 33. Left-hand side of the frame, with stop screw for limiting the travel (end)

d. Replacing the scale

1. Turn the fixing screws of the scale out of the frame and remove the scale by sliding it in upward direction.
2. Fit the new scale in the apparatus and tighten the fixing screws so far that the scale can be moved. Take care that the pointer does not touch the scale.
3. Move the scale so that the initial mark coincides with the pointer.
4. Remove the auxiliary voltage or the short-circuit between terminals L4 and L5.

Note — Because of minor displacements of the chart the capillary need not exactly coincide with the final line of the chart when the pointer is on the last stroke of the scale.

Maintenance

Before starting the maintenance work switch off the mains voltage.

SUMMARY

Once every month (a, Fig. 34)

Clean the guide tracks of the measuring carriage with a cotton cloth and then apply a film of oil.

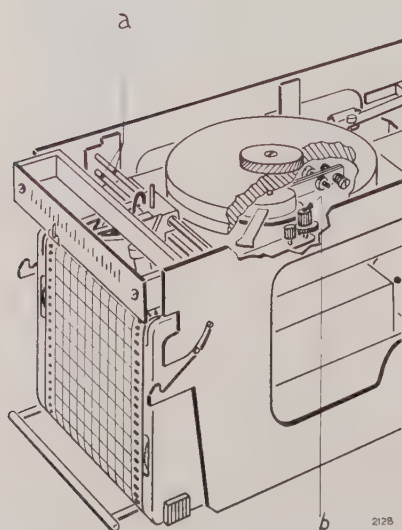
Two times a year (b, Fig. 34).

Apply a few drops of oil to the spindle of the pinion.

Once every two year

Remove the chart cassette and apply a little oil to the spindles of all gearwheels and of the sprocket roller. Take care that no oil gets into the friction coupling of the sprocket roller.

Take the amplifier out of the frame and remove the frame from the apparatus. Raise the measuring-range unit. Open the gear box



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Fig. 34. Lubricating points

now accessible by pulling the rear wall up and sliding the top plate to the rear.

Apply a little oil to the spindles of all gearwheels of the chart-driving system. Almost all bearings are provided with a recess for applying the oil. Take care that no oil gets into the friction coupling.

The spindles of the planet wheels of the differential and the guide track of the clutch coupling must be lubricated too. This only applies to the PR 2400 A/.2, PR 2400 A/.3 and PR 2400 A/.5.

In order to ensure that the apparatus keeps functioning properly, use the oil supplied. For lubricating points *a* and *b* it is allowed to use a thin oil (SAE 10).

General view

LEGEND TO THE FIGURES

- 1 — steel case
- 2 — fixing frame
- 3 — connection box
- 4 — connection block
- 5 — connection terminals for the voltage source
- 6 — switch strip
- 7 — lid of the connection box
- 8 — earth terminal
- 9 — measuring pointer
- 10 — capillary hose
- 11 — tube
- 12 — measuring carriage
- 13 — ink container
- 14 — knob of the measuring potentiometer. In the case of the PR 2400 A/3., PR 2400 A/40 and PR 2400 A/5. this is a rope pulley.
- 15 — case of the measuring potentiometer
- 16 — microswitch(es) with control drum, only with the PR 2400 A/3., PR 2400 A/40 and PR 2400 A/5.
- 17 — chart-speed lever
- 18 — measuring-range unit
- 19 — lever for lifting the amplifier from the frame
- 20 — button "CAL." for checking the supply current of the compensating circuit
- 21 — grip of the amplifier
- 22 — switch "SENSIT." for adjusting the sensitivity
- 23 — amplifier
- 24 — potentiometer "SENSIT." for adjusting the sensitivity
- 25 — potentiometer "ADJ." for adjusting the supply current of the compensating circuit
- 26 — chart-drive motor
- 27 — servomotor
- 28 — frame
- 29 — cassette
- 30 — grip of the frame

- 31 — red setting pointer, only with PR 2400 A/1., PR 2400 A/2. and PR 2400 A/5.
- 32 — adjusting knob for the red setting pointer, only with PR 2400 A/1., PR 2400 A/2. and PR 2400 A/5.
- 33 — green setting pointer, only with PR 2400 A/2.
- 34 — adjusting knob for green setting pointer, only with PR 2400 A/2.

TECHNICAL PART

Measuring principle

The measuring circuit of the PR 2400 A is shown in Fig. 40. The wire-wound measuring potentiometer R_m is fed with a stabilised direct current of known value. As a result, a known voltage (compensating voltage E_d) arises between the points A and B.

The difference between the unknown voltage E_x and the compensating voltage E_d is passed to amplifier V via a vibrator-converter VC.

The alternating voltage now amplified drives servomotor M. The servomotor is mechanically connected to the sliding contact A of the measuring potentiometer. This sliding contact is so adjusted that the compensating voltage E_d then equals the unknown voltage E_x .

Via a cord the measuring carriage (with measuring pointer) is coupled to the sliding contact of the measuring potentiometer without play, so that an accurate indication is obtained.

The measured value can be read on a scale calibrated in mV or $^{\circ}\text{C}$.

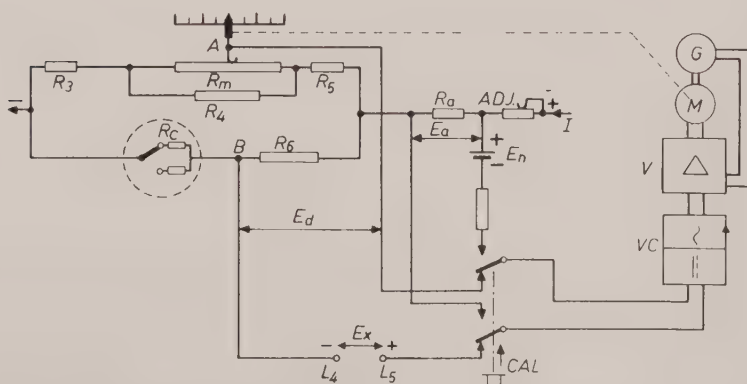


Fig. 40. Principle diagram

To obtain a damping of the measuring carriage a tachometer generator (G) is coupled to the spindle of the servomotor. A generator of this kind produces a voltage which is proportional to the turning speed. This voltage is applied to the input of the amplifier in such a way that the measuring pointer finds the point of equilibrium without any oscillation.

The adjustment of the correct supply current of the compensating circuit is effected with potentiometer "ADJ.". When button "CAL." is pressed the voltage (E_a) across R_a is connected in series with, and in opposition to, the voltage of a normal element (E_n). The difference between these voltages $|E_a - E_n|$ is amplified by amplifier V. Potentiometer "ADJ." is now so turned that $|E_a - E_n| = 0$; in that case there is no input voltage at the amplifier so that the measuring carriage can be placed at any point of the scale.

Resistor R_a is so dimensioned that the supply current of the compensating circuit is then 1 mA.

The resistors R_3 , R_4 , R_5 and R_6 determine the size and the initial value of the measuring range.

By switching in resistor R_c the automatic cold-junction compensation is obtained.

Fault finding

Fault	Check
A. The apparatus does not work	1. Supply voltage at D1 and D2. a. No supply voltage: eliminate fault outside apparatus. b. Supply voltage present: press the female plug and the amplifier. 2. Running of the chart-drive motor. a. Motor works: see under E. b. Motor does not work: apply to PHILIPS Service Organisation.
B. The chart transport does not work *	Running of the chart-drive motor a. Motor does not work: apply to PHILIPS Service Organisation. b. Motor works: – position of the chart-speed lever (i.e. not in zero position). – correct positioning of the chart on the sprocket roller. If no cause found, apply to PHILIPS Service Organisation.
C. Dead zone is too large	Disconnect input voltage and connect auxiliary voltage. Dead zone (p. 41). a. Dead zone remains too large. – friction of guide tracks of measuring carriage. Friction too great: oil the tracks. If the friction remains too great: apply to PHILIPS Service Organisation. – Friction correct: apply to PHILIPS Service Organisation. b. Dead zone eliminated: Disconnect auxiliary voltage. – Internal resistance of the voltage source (max. 200 Ω/mV measuring range). – Earth. If necessary, earth other pole of voltage source (p. 23). – Position of connecting cable. Not parallel to cables carrying high alternating currents (or high alternating voltages); if necessary, measure interference voltage. Interference voltage at the input too high: use screened cable and/or hum filter (PR 7920/02). Interference voltage between input and earth too high: use screened cable and/or trifilar coil + hum filter (PR 7917/10). If no cause found, apply to PHILIPS Service Organisation.

* Remember play in gear transmission of chart-driving mechanism (p. 29).

D. Faulty reading

- Supply current of compensating circuit (p. 39).
If the supply current can not be adjusted, apply to PHILIPS Service Organisation.
 - Connection of the voltage source (undesirable thermo-e.m.f. in the measuring leads?).
 - Position of the switch strip.
 - D.C. voltage between measuring voltage and earth ($1000 \times$ measuring range, max. 100 V).
 - Earth. If necessary, earth other pole of voltage source (p. 23).
 - Leak resistance of capacitor between D4 and D10 (max. 60 M Ω at 20 °C).
- If no cause found, apply to PHILIPS Service Organisation.
-

E. No reading

Replace amplifier by a reserve amplifier.
No result: check connections between amplifier and rest of apparatus (with the help of the diagram).
If connections correct: apply to PHILIPS Service Organisation.

Accessories

HUM FILTER PR 7920/02

a. Introduction

This hum filter is used when the interference voltage at the input terminals is greater than 0.1 % of the measuring range in mV. This manifests itself in an excessive dead zone of the recorder. This filter is capable of attenuating a 50 c/s interference voltage at least $1000 \times$, so that the maximum permissible a.c. voltage at the input terminals becomes equal to the measuring range.

b. Technical data

Attenuation of a 50 c/s interference voltage at the input terminals

• $> 1000 \times$

Dimensions

: $134 \times 91 \times 75$ mm

By applying the hum filter, the following properties of the Miniature Recorder are changed:

Maximum permissible a.c. voltage at the input terminals : $1 \times$ measuring range

Maximum permissible resistance of the voltage source : $200 \Omega/\text{mV}$ with a maximum of $20 \text{ k}\Omega$

Adjusting time of the measuring carriage for the whole scale length : approximately 1 sec at a resistance of the voltage source of $< 10 \text{ k}\Omega$ to maximum 3 sec at a resistance of $20 \text{ k}\Omega$.

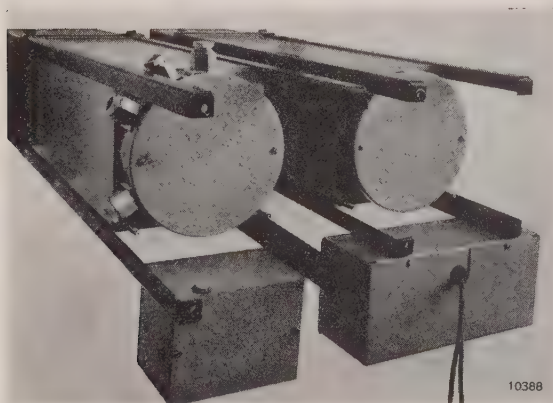


Fig. 41. Mounting of hum filter PR 7920/02 (at the left) and trifilar coil + hum filter PR 7917/10 (at the right)

c. Mounting and connection

Remove the mounting frame of the miniature recorder and fix the filter under this frame by means of the bolts supplied, see Fig. 41. Remove the connections L4—D11 and L5—D12 in the connection box of the recorder.

With the wire-tree supplied, the hum filter must be connected to the miniature recorder as follows:

1. If terminal L4 (—) is earthed,
red wire (terminal 1) to terminal L5
white wires (terminal 2) to terminal L4 and terminal D11
blue wire (terminal 3) to terminal D12
blue-white wire (terminal 4) to terminal D10
2. If terminal L5 (+) is earthed,
red wire (terminal 1) to terminal L4
white wires (terminal 2) to terminal L5 and terminal D12
blue wire (terminal 3) to terminal D11
blue-white wire (terminal 4) to terminal D10

The earthing instructions of the miniature recorder remain effective.

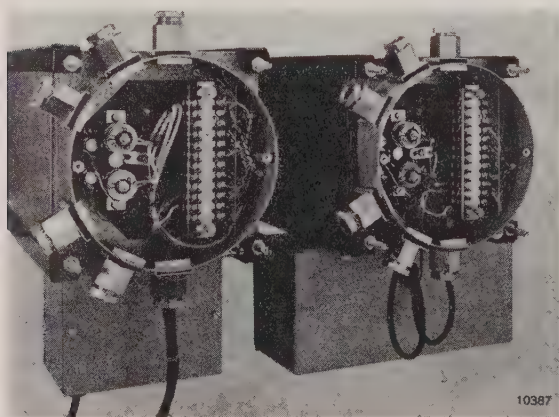


Fig. 42. Connection of the PR 7920/02 and the PR 7917/10

d. Adjustment

To make a critically damped adjustment of the measuring carriage possible, the external resistance should have a certain minimum value. This minimum value is:

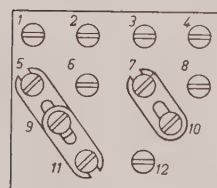
approx. 1 k Ω for a measuring range ≤ 10 mV

approx. 2.2 k Ω for a measuring range between 10 mV and 50 mV

approx. 3.2 k Ω for a measuring range ≥ 50 mV

If the external resistance is smaller than the value mentioned above, it must be increased by using a resistor in series. For this purpose, the filter is fitted with a resistor of 1 k Ω between points 5 and 9 and with a resistor of 2.2 k Ω between points 9 and 11. These resistors are short-circuited with connection strips.

Dependent on the position of the strips, the switched on series-resistance is 0, 1, 2.2 or 3.2 k Ω , see Fig. 43.

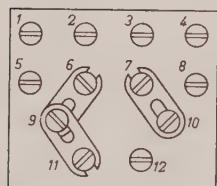


series resistance 0

connections 7—10

9—5

9—11

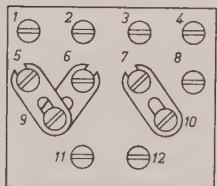


series resistance 1 k Ω

connections 7—10

9—6

9—11

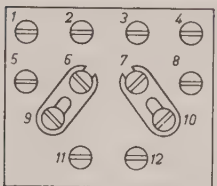


series resistance 2.2 k Ω

connections 7—10

9—6

9—5



series resistance 3.2 k Ω

connections 7—10

9—6

9—6

Fig. 43. Position of the connection strips

Note — In the case of temperature measurements, the magnitude of the measuring range can be determined by means of the temperature/mV-table of the thermocouple.

If a critically damped adjustment of the measuring carriage proves to be impossible in this manner, the external resistance should be increased in case of overshoot or decreased in case of a continued dead zone. This can be effected by changing the position of the connection strips.

TRIFILAR COIL + HUM FILTER PR 7917/10

a. Introduction

This accessory is used when the interference voltage between the input terminals and earth is greater than the measuring range in mV. A 50-c/s interference voltage is approximately $1000 \times$ attenuated by the trifilar coil, so that the maximum permissible a.c. voltage between the input terminals and earth becomes equal to $1000 \times$ the measuring range with a maximum of 75 V.

b. Technical data

Attenuation of a 50-c/s interference voltage between the input and earth

: approx. $1000 \times$

Dimensions

: $195 \times 91 \times 75$ mm

Properties of the miniature recorder that change when use is made of the PR 7917/10.

Maximum permissible a.c. voltage between the input terminals and earth

: $1000 \times$ measuring range, with a maximum of 75 V

Maximum permissible resistance of the voltage source

: 100 Ω

c. Mounting and connection

Remove the mounting frame from the miniature recorder and fix the case under this frame with the aid of the bolts supplied, see Fig. 41.

Remove the connections L4—D11 and L5—D12 in the connection

box of the recorder. Connect the accessory to the miniature recorder by means of the wire tree in the following way:

1. From the wires with cable tags:
 the white wire (terminal 1, at the right) to terminal L4
 the red wire (terminal 4, at the right) to terminal L5.
2. From the wires without cable tags:
 the blue wire (terminal 2, at the left) to terminal D12
 the white wire (terminal 3, at the left) to terminal D11
 the screening to terminal D10

Besides, terminal 2 of the trifilar coil (at the right) must be connected to the point of application of the interference voltage, keeping the resistance of the connection as low as possible.

If the point of application of the interference voltage is unknown, and if the pick-up leads are sufficiently low-ohmic, terminal 2 of the trifilar coil must be connected to terminal 1 or terminal 4 of the same unit.

If the pick-up leads are not low-ohmic then this terminal must be connected to one of the connection points of the pick-up on the measuring point via a separate, low-ohmic, insulated wire. For this purpose the screening may be used, if required, provided that it is insulated.

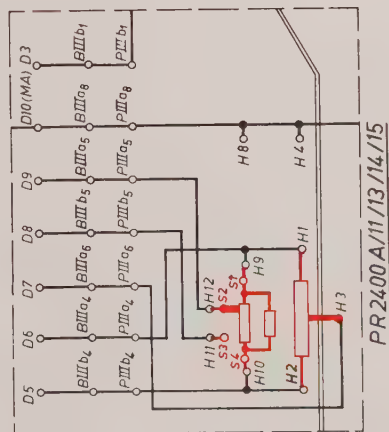
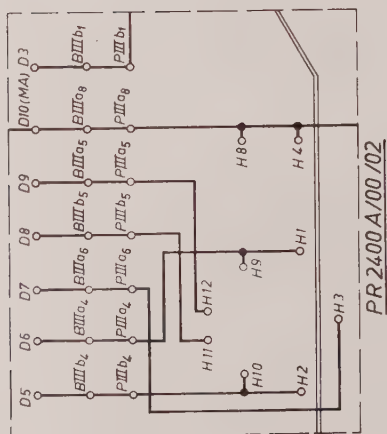
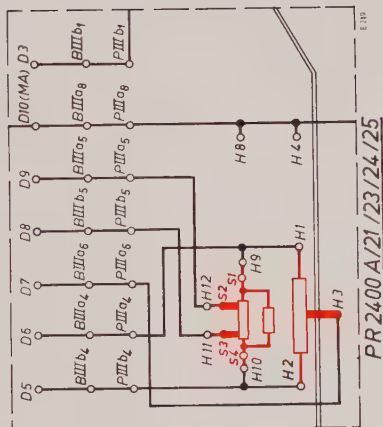
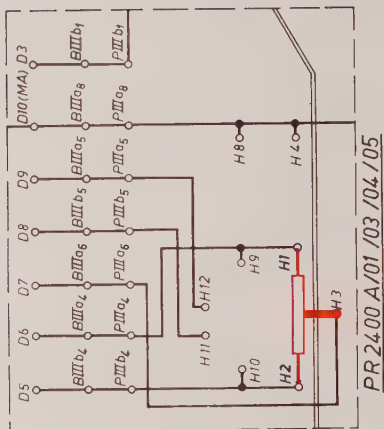
The connection must so be chosen that the dead zone is as small as possible.

To the terminals 6 or 7 of the trifilar coil (at the right) two wires are connected. Try if the dead zone becomes smaller, when these wires are connected to the other terminal of the hum filter (at the left).

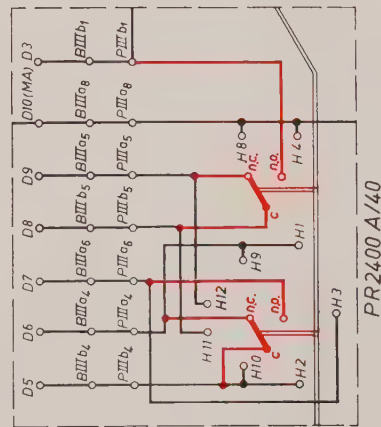
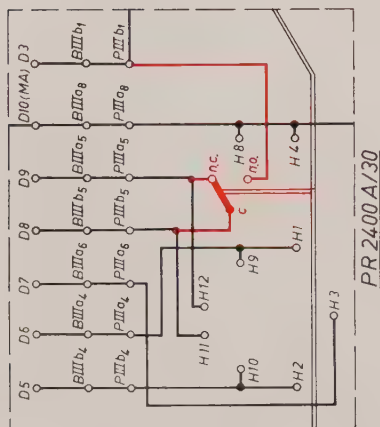
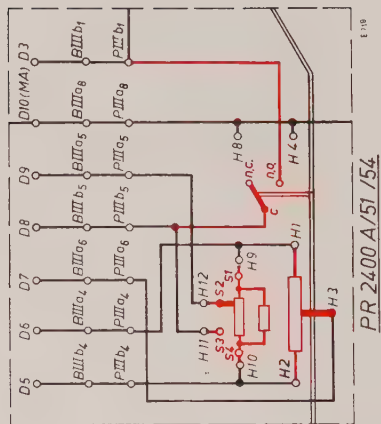
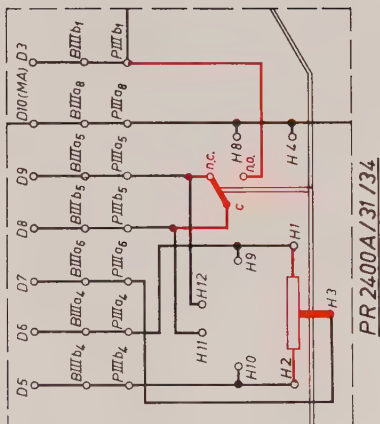
Note — For checking the dead zone, the switch strips must be placed in the correct position, see page 60.

d. Adjustment

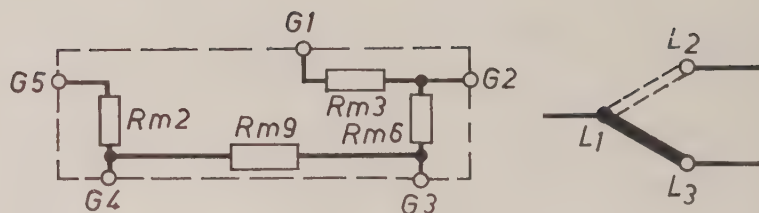
The switch strips of the hum filter of this accessory must be adjusted in the same way as in the case of hum filter PR 7920/02, see the relevant section.



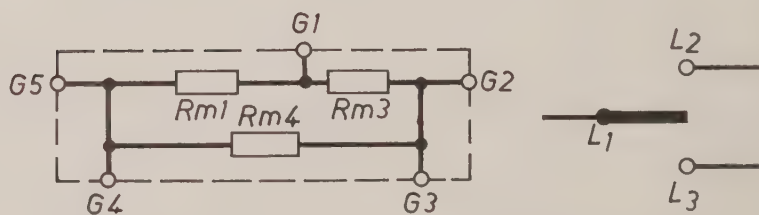
Complementary diagrams



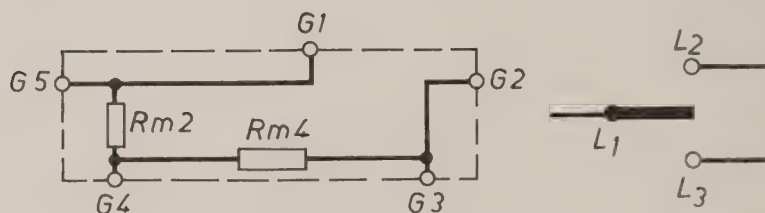
Complementary diagrams



Measuring-range unit for temperature measurements PR 416, A/..



Measuring-range unit for mV-measurements PR 4160 M/..



Measuring-range unit for temperature measurement PR 416, A/..

List of electrical parts

(subject to alterations)

Capacitors

C1	100 μ F	25 V
C2	100 μ F	25 V
C3	100 μ F	25 V
C4	100 μ F	16 V
C5	100 μ F	16 V
C6	25 μ F	25 V
C7	250 μ F	16 V
C8	100 μ F	25 V
C9	25 μ F	25 V
C10	100 μ F	25 V
C11	25 μ F	25 V
C12	100 μ F	16 V
C13	100 μ F	16 V
C14	25 μ F	25 V
C15	100 μ F	25 V
C16	100 μ F	16 V
C17	250 μ F	16 V
C18	1 μ F	125 V
C19	64 μ F	25 V
C20	100 μ F	25 V
C21	470 or 680 nF*	125 V
C22	64 μ F	25 V
C25	40 μ F	125 V
C26	330 nF	700 V
C27	330 nF	700 V
C28	12 nF	

Resistors

Rm1	resistors of the measuring-range unit		
Rm2			
Rm3			
Rm4			
Rm6			
Rm9			
R1	3.3 k Ω	$\pm 1\%$	0.125 W
R2	6.8 k Ω	$\pm 1\%$	0.125 W
R3	1.5 k Ω	$\pm 5\%$	0.25 W
R4	1.5 k Ω	$\pm 1\%$	0.125 W
R5	10 k Ω	$\pm 1\%$	0.125 W
R6	390 Ω	$\pm 1\%$	0.125 W
R7	390 Ω	$\pm 1\%$	0.125 W
R8	6.8 k Ω	$\pm 1\%$	0.125 W
R9	100 Ω	$\pm 1\%$	0.125 W
R10	5.6 k Ω	$\pm 1\%$	0.125 W
R11	220 Ω	$\pm 1\%$	0.125 W
R12	39 k Ω	$\pm 1\%$	0.125 W
R13	100 Ω	$\pm 1\%$	0.125 W
R14	8.2 k Ω	$\pm 1\%$	0.125 W
R16	11 k Ω	$\pm 1\%$	0.125 W
R17	5.6 k Ω	$\pm 1\%$	0.125 W
R18	3.3 k Ω	$\pm 1\%$	0.125 W

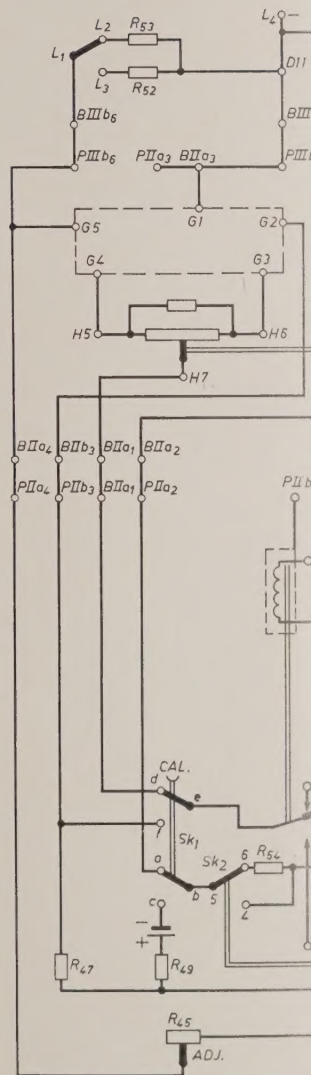
R19	1.2 k Ω	$\pm 1\%$	0.125 W
R20	120 Ω	$\pm 1\%$	0.125 W
R21	680 Ω	$\pm 1\%$	0.125 W
R22	2.2 k Ω	$\pm 1\%$	0.125 W
R23	100 Ω	$\pm 1\%$	0.125 W
R24	1.5 k Ω	$\pm 1\%$	0.125 W
R25	150 Ω	$\pm 1\%$	0.125 W
R26	12 k Ω	$\pm 1\%$	0.125 W
R27	4.7 k Ω	$\pm 1\%$	0.125 W
R28	2.7 k Ω	$\pm 1\%$	0.125 W
R29	100 Ω	$\pm 1\%$	0.125 W
R30	1.2 k Ω	$\pm 1\%$	0.125 W
R31	33 Ω	$\pm 1\%$	0.125 W
R32	680 Ω	$\pm 1\%$	0.125 W
R33	1 Ω	$\pm 2\%$	0.4 W
R34	220 Ω	$\pm 5\%$	1 W
R35	8.2...12 k Ω *		
R36	120...180 Ω *		
R37	10 Ω	$\pm 1\%$	0.125 W
R38	22 k Ω	$\pm 5\%$	0.25 W
R39	12 k Ω	$\pm 5\%$	0.25 W
R40	12 k Ω	$\pm 5\%$	0.25 W
R41	10 k Ω	$\pm 2\%$	0.7 W
R42	1.2 k Ω	$\pm 2\%$	0.6 W
R43*			
R44	4.3 k Ω	$\pm 2\%$	0.6 W
R45	2.5 k Ω	$\pm 5\%$	1 W
R46	250 Ω	$\pm 5\%$	1 W
R47	1018 Ω	$\pm 0.1\%$	
R48	5 k Ω	$\pm 5\%$	1 W
R49	22 k Ω	$\pm 5\%$	0.25 W
R50	390 Ω	$\pm 5\%$	0.25 W
R51	15 k Ω	$\pm 5\%$	0.25 W
R52	100 Ω , manganin **		
R53	108.2 Ω at 20°C, copper **		
R54	3.9 k Ω		

Transistors

Ts1	OC 45	Ts6	OC 45
Ts2	OC 45	Ts7	OC 30
Ts3	OC 45	Ts8	ASZ 15
Ts4	OC 45	Ts9	ASZ 15
Ts5	OC 45	Ts10	OC 72

Diodes

Gr1	OA 85	Gr9	OA 210
Gr2	OA 85	Gr10	OA 210
Gr5	OA 5	Gr11	OA 210
Gr6	OA 5	Gr12	OA 210
Gr7	OA 5	Gr13	Z 8
Gr8	OA 5		



* The proper value is selected when the apparatus is being manufactured.

** Special resistor for temperature measurements.

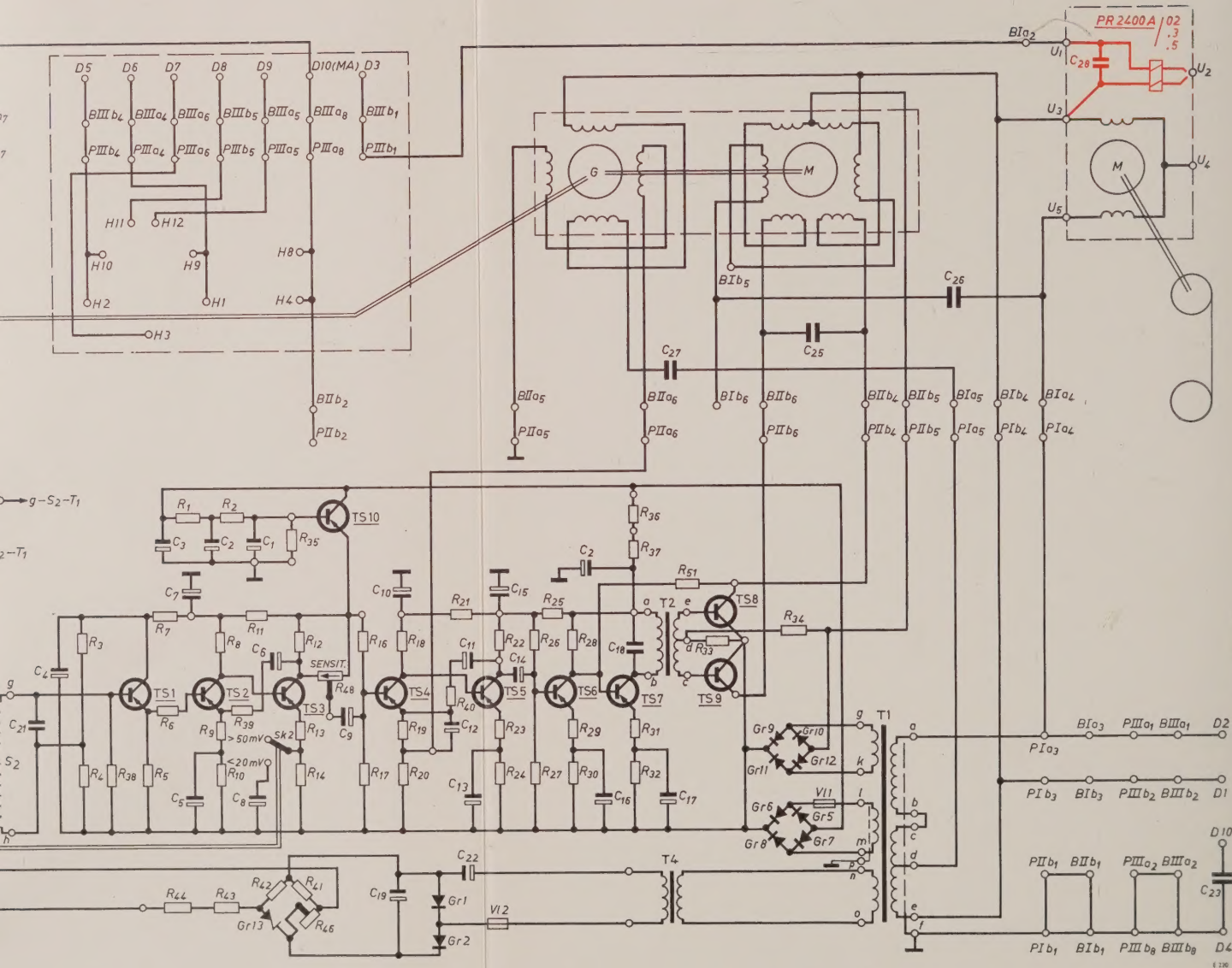


Fig. 44. Diagram (subject to alterations)

MP MASTER



MA24636